Benefits & Challenges of 5D BIM adoption: Perception of Quantity Surveyors.

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ABSTRACT
5D Building Information Modeling (BIM) is a technology that integrates 3D design, construction, and maintenance information with time and cost data, allowing for the creation of a dynamic model of a building or infrastructure project towards its enhanced management. The study aims to assess the perception of Nigerian Quantity Surveyors' perception of the benefits and challenges of adopting 5D BIM. The review method of data collection was used, and the data obtained were analysed using descriptive. The results highlight the potential benefits of using 5D BIM, which include improving project planning and decision-making, reducing errors and rework, and enhancing collaboration among project stakeholders. The findings also identified several challenges to the widespread adoption of 5D BIM, including the need for standardisation and interoperability, the lack of skilled users, and the high initial costs of implementing the technology. Overall, this study provides a comprehensive overview of the potential benefits of 5D BIM and the challenges affecting the facilitation of its widespread adoption in the construction industry. This implies and poses a major task for the Nigerian Institute of Quantity Surveyors to embark on a systematic and deliberate approach to BIM software training for members in construction-related themes. The result also recommends accreditation agencies and tertiary institutions review the current curriculum to incorporate the concept of 5D BIM into teaching and learning to equip students with the digital skills required for the fourth industrial revolution.

Keywords: 5D BIM, cost management; construction 4.0; digital skills; project planning; Standardisation.

1. INTRODUCTION

Building Information Modelling (BIM) has revolutionized the construction industry, changing the way buildings are designed, constructed, and managed(Malagnino et al., 2021). The use of BIM technology has allowed for more efficient and accurate project delivery, reducing the risk of errors and delays, and increasing collaboration among project stakeholders(Hautala et al., 2017). One of the most significant advancements in BIM technology is 5D BIM, which adds cost estimation and management capabilities to the traditional 3D model, and time scheduling to the 4D model(Abdullahi B Saka et al., 2019).

5D BIM is rapidly gaining traction in the construction industry, and many construction professionals believe that it has the potential to transform construction cost management. However, despite its potential benefits, there are still many challenges associated with the adoption and implementation of 5D BIM(Le, 2021). Quantity surveyors, who are responsible

for managing construction costs, play a critical role in the adoption and implementation of 5D BIM(Seyis, 2020). Therefore, it is essential to understand their perception of the benefits and challenges associated with adoption of 5D BIM.

This paper provides an in-depth analysis of the benefits and challenges of 5D BIM adoption from the perspective of quantity surveyors. The paper begins by providing a brief overview of BIM and its importance in the construction industry. The significance of 5D BIM in construction cost management is also highlighted. A thorough review of the literature is then presented, focusing on the definition and benefits of 5D BIM, as well as case studies of successful implementation. The research methodology is then discussed, detailing the research design. The results are presented and analyzed, discussing the benefits and challenges of 5D BIM adoption from the perspective of quantity surveyors. The paper also examines how quantity surveyors perceive the benefits of 5D BIM adoption.

The paper concludes by summarizing the key findings, implications of the study, and recommendations for future research. In conclusion, the adoption and implementation of 5D BIM in construction cost management has the potential to revolutionize the construction industry.

2. RESEARCH METHODOLOGY

The method of review utilized in this investigation is one that is predicated on content analysis. Because of its vast applicability and general acceptance as an effective strategy for reviewing and synthesizing literature and justifying results, this method has been widely employed in engineering and construction management. This is owing to its widespread applicability. (Li et al., 2018; Onososen & Musonda, 2022). The Scopus database was utilized to choose a number of first-tier papers linked to BIM. This was done in order to locate articles that were relevant to the aims of the study. These papers were selected from respected and authoritative academic journals in topics such as engineering and construction management, science, technology, safety, and human factors, amongst others. Figure 1 illustrates the steps that were taken to pick the articles that were used.

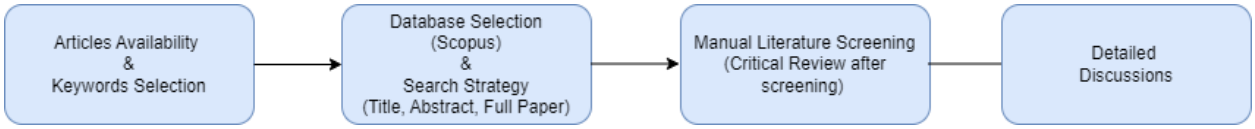

Figure 1. Research Method Process.

3. DISCUSSION AND FINDINGS

3.1 Explanation of 5D BIM and its benefits

Building Information Modeling (BIM) is a digital representation of the physical and functional characteristics of a building or infrastructure. It is a 3D model that includes all the necessary information about a project, including dimensions, material specifications, and construction processes. 5D BIM takes the 3D model one step further by incorporating cost data, which allows construction professionals to create accurate project budgets and monitor project costs in real-time (Silvestre & Pyl, 2020).

5D BIM integrates the 3D model with cost data, allowing construction professionals to create detailed project budgets and monitor project costs throughout the project's lifecycle. 5D BIM uses cost data to simulate various construction scenarios, enabling project teams to make informed decisions that balance project scope, cost, and time constraints. The five dimensions of 5D BIM are:

3.1.1 3D Model: The 3D model represents the physical characteristics of the building or infrastructure, including dimensions, geometry, and spatial relationships.

3.1.2 Time: Time refers to the construction schedule or timeline, including the sequence of construction activities, duration, and dependencies.

3.1.3 Cost: Cost data includes the cost of materials, labor, equipment, and other expenses associated with the project.

3.1.4 Sustainability: Sustainability refers to the environmental impact of the project, including energy consumption, carbon emissions, and waste reduction.

3.1.5 Facility Management: Facility management includes the ongoing maintenance and operation of the building or infrastructure, including equipment maintenance, energy management, and occupant comfort.

3.2 The benefits of 5D BIM are numerous and significant. The following are some of the key benefits of 5D BIM:

3.2.1 Accurate Cost Estimating: 5D BIM enables construction professionals to create accurate and detailed project budgets by incorporating cost data into the 3D model. By using 5D BIM, construction professionals can estimate material quantities accurately, reducing waste and improving efficiency. Additionally, 5D BIM enables project teams to simulate different scenarios and analyze the impact of design changes on project cost. This helps to identify potential cost overruns early in the project lifecycle, enabling project teams to make informed decisions and take corrective action to stay on budget (Information, 2019).

3.2.2 Improved Project Scheduling: By integrating cost data with the 3D model, construction professionals can generate detailed project schedules that take into account the cost implications of different design and construction approaches. This helps project teams to optimize the construction process, reduce downtime, and minimize the duration of the project. Additionally, 5D BIM provides tools for simulating various project scenarios, allowing project teams to assess the impact of different scheduling approaches on project cost (Malagnino et al., 2021).

3.2.3 Enhanced Project Control: By integrating cost data into the 3D model, project teams can track project progress and cost in real-time. This level of project control enables project teams to identify potential cost overruns early in the project lifecycle and take

corrective action to keep the project on budget. Additionally, 5D BIM enables construction professionals to generate detailed project reports that provide stakeholders with a comprehensive view of the project's cost and progress (Nabizadeh & Hossein, 2021).

3.2.4 Improved Collaboration and Communication: By providing a shared platform for project information, 5D BIM improves communication and collaboration between architects, engineers, contractors, and building owners. This level of collaboration ensures that everyone involved in the project is on the same page, reducing the likelihood of miscommunications and errors. Additionally, 5D BIM enables project teams to share cost data in real-time, enabling stakeholders to make informed decisions and take corrective action to keep the project on budget (Jiang et al., 2021).

3.2.5 Increased Project Efficiency and Effectiveness: By improving cost estimating, project scheduling, project control, collaboration, and communication, 5D BIM helps project teams to deliver projects more efficiently (Azhar et al., 2011).

3.3 Advantages of 5D BIM in quantity surveying

3.3.1 Accurate Cost Estimation: One of the primary advantages of 5D BIM in quantity surveying is accurate cost estimation. Quantity surveyors use 5D BIM to generate accurate and detailed project budgets by incorporating cost data into the 3D model. This allows for accurate estimating of material quantities, reducing waste and improving efficiency. Additionally, 5D BIM enables quantity surveyors to simulate different scenarios and analyze the impact of design changes on project cost. This helps to identify potential cost overruns early in the project lifecycle, enabling quantity surveyors to make informed decisions and take corrective action to stay on budget (Malagnino et al., 2021).

3.3.2 Improved Cost Management: Another advantage of 5D BIM in quantity surveying is improved cost management. Quantity surveyors use 5D BIM to monitor project costs throughout the project's lifecycle, enabling them to track project progress and cost in real-time. This level of project control enables quantity surveyors to identify potential cost overruns early in the project lifecycle and take corrective action to keep the project on budget. Additionally, 5D BIM enables quantity surveyors to generate detailed project reports that provide stakeholders with a comprehensive view of the project's cost and progress (Nasila & Cloete, 2018).

3.3.3 Enhanced Project Control:5D BIM provides enhanced project control for quantity surveyors. By integrating cost data into the 3D model, quantity surveyors can track project progress and cost in real-time. This level of project control enables quantity surveyors to identify potential cost overruns early in the project lifecycle and take corrective action to keep the project on budget. Additionally, 5D BIM provides tools for simulating various project scenarios, allowing quantity surveyors to assess the impact of different scheduling approaches on project cost (Adam et al., 2020).

3.3.4 Improved Collaboration and Communication: 5D BIM improves collaboration and communication between architects, engineers, contractors, and building owners. Quantity surveyors can use 5D BIM to collaborate with other project stakeholders and share cost data in real-time, enabling stakeholders to make informed decisions and take corrective action to keep the project on budget. Additionally, 5D BIM provides a shared platform for project information, improving communication and collaboration between all project stakeholders (Genova, 2019).

3.3.5 Increased Efficiency and Effectiveness:5D BIM helps quantity surveyors to deliver projects more efficiently and effectively. By improving cost estimating, cost management, project control, collaboration, and communication, 5D BIM enables quantity surveyors to deliver projects on time and within budget. Additionally, 5D BIM provides tools for analyzing project data and identifying areas for improvement, enabling quantity surveyors to optimize the construction process and improve project efficiency (B. Soust-Verdaguer et al., 2021).

3.3.6 Improved Visualization:5D BIM allows quantity surveyors to visualize the construction process in greater detail, which enables them to make informed decisions about material quantities and construction methods. Quantity surveyors can use 5D BIM to generate detailed 3D models that provide a realistic representation of the building or infrastructure. This enables quantity surveyors to identify potential issues early in the design process, reducing the likelihood of costly errors and delays (Röck et al., 2018).

3.3.7 Risk Mitigation:5D BIM helps quantity surveyors to mitigate project risks by providing a comprehensive view of the project's cost and progress. By tracking project costs in real-time, quantity surveyors can identify potential cost (Liu et al., 2019)

3.4 Challenges in 5D BIM adoption and implementation

3.4.1 Lack of Standardization: One of the primary challenges in 5D BIM adoption and implementation is the lack of standardization in the industry. While BIM standards have been developed in many countries, they are not consistently applied, resulting in a lack of interoperability between different BIM software platforms. This lack of standardization makes it difficult for construction teams to collaborate effectively and share project data in real-time, reducing the benefits of 5D BIM (Altohami et al., 2021).

3.4.2 Skills Gap: Another challenge in 5D BIM adoption and implementation is the skills gap among construction professionals. While BIM technology is becoming increasingly prevalent, many construction professionals lack the necessary skills and knowledge to use the technology effectively. This can result in a lack of adoption or ineffective use of 5D BIM, reducing the potential benefits of the technology (Ayman et al., 2018).

3.4.3 Integration with Existing Processes: Integrating 5D BIM with existing construction processes can be a challenge. Construction teams may be resistant to change, and integrating 5D BIM into existing processes may require significant changes to

established workflows. Additionally, integrating 5D BIM with other software applications used in construction, such as project management or scheduling software, can be challenging (Sorce & Issa, 2021).

3.4.4 Cost: The cost of implementing 5D BIM can also be a challenge for construction firms. BIM software can be expensive, and implementing the technology may require additional hardware, training, and support costs. Additionally, the cost of implementing 5D BIM may be prohibitive for smaller construction firms, reducing their ability to compete with larger firms that have already adopted the technology.

3.4.5 Data Management: Effective data management is critical for the success of 5D BIM. Construction projects generate vast amounts of data, and managing this data effectively can be a challenge. Ensuring data quality and accuracy, and managing data security and privacy are important considerations in 5D BIM implementation. Additionally, construction teams must establish protocols for sharing data and maintaining data integrity throughout the project lifecycle (Feng et al., 2020).

3.4.6 Legal and Contractual Issues: The implementation of 5D BIM can also raise legal and contractual issues. For example, ownership of project data can be a contentious issue, particularly when multiple parties are involved in the project. Additionally, contractual issues, such as liability for errors in the 5D BIM model, must be addressed in project contracts (Babatunde et al., 2021).

3.4.7 Resistance to Change: Resistance to change is a common challenge in any technological implementation, and 5D BIM is no exception. Construction teams may be resistant to change, particularly if they are accustomed to traditional construction methods. This resistance can manifest in a lack of adoption or ineffective use of 5D BIM, reducing the potential benefits of the technology (Chen et al., 2021).

3.4.8 Lack of Industry Awareness: Finally, a lack of industry awareness can also be a challenge in 5D BIM adoption and implementation. Many construction firms may not be aware of the benefits of 5D BIM, or may not understand how to effectively implement the technology. Additionally, there may be a lack of awareness among clients and stakeholders, reducing demand for 5D BIM services (Taher & Elbeltagi, 2021).

3.5 Discussion of the benefits of 5D BIM adoption in construction cost management

3.5.1 Enhanced Cost Control: One of the key benefits of 5D BIM adoption is enhanced cost control. By incorporating cost data into the BIM model, construction teams can track costs in real-time, identify cost overruns early, and take corrective action. This early identification of cost overruns can result in significant savings for construction firms, reducing the risk of project delays or cancellations (Sandberg et al., 2019).

3.5.2 Improved Collaboration: 5D BIM also improves collaboration among construction teams, reducing the risk of errors or miscommunications. Construction teams can work collaboratively on the same BIM model, allowing for real-time collaboration and

problem-solving. This improved collaboration can result in more accurate cost estimates and better cost control throughout the project lifecycle (Abdullahi B Saka et al., 2019).

3.5.3 Accurate Cost Estimation: Another benefit of 5D BIM adoption is more accurate cost estimation. By incorporating cost data into the BIM model, construction teams can generate more accurate cost estimates, reducing the risk of cost overruns. Accurate cost estimation is critical in construction, as cost overruns can result in project delays, cancellations, or legal disputes (Abdullahi B. Saka et al., 2020).

3.5.4 Improved Planning and Scheduling: 5D BIM can also improve planning and scheduling, providing construction teams with real-time data on cost and schedule performance. Construction teams can use this data to adjust the project schedule and resources, ensuring that the project is delivered on time and within budget. This improved planning and scheduling can result in significant time and cost savings for construction firms (A. O. Onososen et al., 2022).

3.5.5 Reduced Rework: Incorporating cost data into the BIM model can also reduce the risk of rework, reducing costs and improving project efficiency. By providing real-time cost analysis and management, construction teams can identify and correct errors early, reducing the need for costly rework later in the project lifecycle (Liphadzi et al., 2022).

3.5.6 Improved Decision Making:5D BIM also improves decision-making by providing construction teams with real-time data on cost and schedule performance. This data can be used to make informed decisions about project scope, resources, and scheduling, ensuring that the project is delivered on time and within budget. This improved decision-making can result in significant cost savings for construction firms, reducing the risk of project delays or cancellations (Onososen & Musonda, 2022).

3.5.7 Enhanced Risk Management: 5D BIM can also enhance risk management, providing construction teams with real-time data on project risks and vulnerabilities. Construction teams can use this data to identify potential risks and take corrective action early, reducing the risk of project delays or cancellations. This enhanced risk management can result in significant cost savings for construction firms, reducing the risk of legal disputes or project failure (Onososen & Musonda, 2021).

3.5.8 Improved Client Communication: Finally, 5D BIM can improve client communication, providing clients with real-time data on project cost and schedule performance. Clients can use this data to track project progress and make informed decisions about project scope and resources. This improved client communication can result in greater client satisfaction and repeat business for construction firms (Onososen & Musonda, 2022a).

3.6 Explanation of how quantity surveyors perceive the benefits of 5D BIM adoption.

Quantity surveyors are responsible for the management of costs and procurement of resources throughout the construction project lifecycle. They play a crucial role in ensuring that projects are delivered on time and within budget. The benefits of 5D BIM adoption are particularly

relevant to quantity surveyors as they directly impact their role in construction project management.

3.6.1 Improved Cost Control: The most significant benefit of 5D BIM adoption for quantity surveyors is improved cost control. By incorporating cost data into the BIM model, construction teams can track costs in real-time, identify cost overruns early, and take corrective action. Quantity surveyors can use this real-time cost data to monitor project costs and make informed decisions about project scope and resources. This early identification of cost overruns can result in significant savings for construction firms, reducing the risk of project delays or cancellations (Santos et al., 2020).

3.6.2 Enhanced Collaboration: 5D BIM adoption also enhances collaboration among construction teams, reducing the risk of errors or miscommunications. Quantity surveyors can work collaboratively with other construction team members on the same BIM model, allowing for real-time collaboration and problem-solving. This improved collaboration can result in more accurate cost estimates and better cost control throughout the project lifecycle (Ahmed & Suliman, 2020).

3.6.3 Accurate Cost Estimation: Another benefit of 5D BIM adoption for quantity surveyors is more accurate cost estimation. By incorporating cost data into the BIM model, construction teams can generate more accurate cost estimates, reducing the risk of cost overruns. Quantity surveyors can use this data to develop more accurate cost plans and budgets, ensuring that the project is delivered on time and within budget (Naneva et al., 2020).

3.6.4 Improved Planning and Scheduling: 5D BIM can also improve planning and scheduling, providing quantity surveyors with real-time data on cost and schedule performance. Quantity surveyors can use this data to adjust the project schedule and resources, ensuring that the project is delivered on time and within budget. This improved planning and scheduling can result in significant time and cost savings for construction firms (Sibenik & Kovacic, 2021).

3.6.5 Reduced Rework: Incorporating cost data into the BIM model can also reduce the risk of rework, reducing costs and improving project efficiency. By providing real-time cost analysis and management, construction teams can identify and correct errors early, reducing the need for costly rework later in the project lifecycle. This reduced rework can result in significant cost savings for construction firms (Nasila & Cloete, 2018).

3.6.6 Improved Decision Making: 5D BIM also improves decision-making by providing quantity surveyors with real-time data on cost and schedule performance. This data can be used to make informed decisions about project scope, resources, and scheduling, ensuring that the project is delivered on time and within budget. This improved decision-making can result in significant cost savings for construction firms, reducing the risk of project delays or cancellations (Azhar et al., 2011).

3.6.7 Enhanced Risk Management: 5D BIM can also enhance risk management, providing quantity surveyors with real-time data on project risks and vulnerabilities. Quantity surveyors can use this data to identify potential risks and take corrective action early, reducing the risk of project delays or cancellations. This enhanced risk management can result in significant cost savings for construction firms, reducing the risk of legal disputes or project failure (Saka et al., 2019).

4. STRATEGIES

4.1.1 Change Management: One of the biggest challenges in 5D BIM adoption is change management. 5D BIM requires a significant shift in the way construction teams collaborate and manage projects. This shift can be difficult for construction teams that are used to traditional project management methods. To overcome this challenge, construction firms should invest in change management training to help their employees adapt to new workflows and processes. Change management training should focus on building a culture of collaboration and openness to new ideas, which can help ease the transition to 5D BIM (Malagnino et al., 2021).

4.1.2 Technical Expertise: Another challenge in 5D BIM adoption is the need for technical expertise. 5D BIM requires specialized software and technical skills that may not be available in-house. To overcome this challenge, construction firms should invest in hiring or training employees with the necessary technical skills. This investment in technical expertise can pay off in the long run by improving project efficiency and reducing the risk of errors (Lim et al., 2021).

4.1.3 Data Management: 5D BIM adoption also requires effective data management. The large amount of data generated by BIM models can be overwhelming, making it difficult to manage and analyze. To overcome this challenge, construction firms should invest in data management solutions that can store, analyze, and report on data generated by the BIM model. Data management solutions should be scalable, secure, and user-friendly, allowing construction teams to easily access and analyze data (Mellado et al., 2020).

4.1.4 Cost: The cost of 5D BIM adoption can be a significant challenge for construction firms, especially smaller firms with limited resources. To overcome this challenge, construction firms should carefully evaluate the costs and benefits of 5D BIM adoption and develop a budget that includes the necessary software, hardware, and training. Construction firms should also consider partnering with other firms to share the costs of 5D BIM adoption, reducing the financial burden on any one firm.

4.1.5 Standardization: Standardization is another challenge in 5D BIM adoption. There is currently no industry-wide standard for 5D BIM, making it difficult for construction firms to collaborate effectively. To overcome this challenge, construction firms should participate in industry groups and collaborate with other firms to develop standardized

BIM workflows and processes. Standardization can help reduce the risk of errors and improve collaboration among construction teams.

4.1.6 Legal and Contractual Issues: Legal and contractual issues can also be a challenge in 5D BIM adoption. BIM models contain sensitive information that must be protected, and there may be legal and contractual issues related to ownership, liability, and intellectual property. To overcome this challenge, construction firms should work with legal experts to develop contracts that address these issues and protect the interests of all parties involved in the project.

4.1.7 Resistance to Change: Finally, resistance to change can be a significant challenge in 5D BIM adoption. Some employees may resist the adoption of new technology or workflows, which can hinder overcoming challenges in 5D BIM adoption.

5.0 CONCLUSION

In conclusion, 5D BIM is an advanced level of BIM that integrates cost data into the model, providing real-time cost analysis and management throughout the project lifecycle. The benefits of 5D BIM adoption in construction cost management are numerous, including improved collaboration, increased efficiency, reduced risk of errors, and better decision-making. However, there are also several challenges that must be overcome for successful implementation, including change management, technical expertise, integration with legacy systems, data management, cost, standardization, legal and contractual issues, and resistance to change. To overcome these challenges, construction firms should invest in change management training to help their employees adapt to new workflows and processes, hire or train employees with the necessary technical skills, invest in software solutions that can integrate with legacy systems, develop scalable data management solutions, carefully evaluate the costs and benefits of 5D BIM adoption, participate in industry groups to develop standardized workflows and processes, work with legal experts to develop contracts that address legal and contractual issues, and address resistance to change through effective communication and training. The successful adoption of 5D BIM requires a comprehensive strategy that addresses these challenges and leverages the benefits of 5D BIM in construction cost management. By adopting 5D BIM, construction firms can improve their project efficiency, reduce the risk of errors, and make better-informed decisions, leading to improved project outcomes and increased profitability. It is, therefore, important for construction firms to evaluate the potential benefits and challenges of 5D BIM adoption and develop a comprehensive strategy to ensure successful implementation. As technology continues to advance, 5D BIM will become an increasingly essential tool in construction cost management, and construction firms that embrace this technology will have a competitive advantage in the industry.

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